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Business Cases and Business Strategies to Encourage Market Uptake

Addressing Barriers for the Market Uptake of Recommended Heating and Cooling Solutions - Heat Roadmap Europe 4

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2050

Heat Roadmap Europe

A low-carbon heating and cooling strategy

Business Cases and Business Strategies to Encourage Market Uptake

Addressing Barriers for the Market Uptake of
Recommended Heating and Cooling Solutions

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1. Introduction

In Europe, there is a clear, long-term objective to decarbonise the energy system. The Heat Roadmap Europe 4 (HRE4) project, co-funded by the European Union, seeks to enable new policies and prepare the ground for new investments by creating more certainty in relation to the changes that are required.

HRE4 provides new capacity and skills for lead-users in the heating and cooling (H&C) sector, including policy-makers, industry, and researchers at local, national, and EU levels. This is done by developing the data, tools, methodologies, and results necessary to quantify the impact of implementing more energy efficient measures on both the demand and supply side of the sector.

This document functions as one of these tools and outlines the identified business strategies in relation to the most important solutions recommended by the HRE4 project. The term 'strategy' refers to an identification of barriers to the uptake and deployment of such recommended H&C solutions, followed by guidelines on how to address these barriers in an effective and economically-feasible way.

Section 4.2 describes possible business strategies for key HRE4-related technologies on how to increase their market share. These strategies have been built on the scientific and technologically-neutral key recommendations derived from HRE4 analysis of the fourteen EU Member States with the largest heat demand in the EU28¹. The report distinguishes potential solutions for the barriers from a business perspective which will facilitate dissemination of the recommendations among the target audiences.

A detailed description of five different business cases that have already been implemented in some of the HRE4 countries is included in section 5. Though obviously many more relevant examples exist than found here, these particular good practices have already successfully contributed to the popularisation of energy decarbonisation methods, and therefore have been chosen for further emphasis in this document due to their clear replicability potential.

¹ Though insights from HRE4 should be quite applicable across Europe, the project especially concentrates on those fourteen countries with the highest H&C demands: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, the Netherlands, Poland, Romania, Spain, Sweden and the United Kingdom.

2. Methodology for developing business strategies

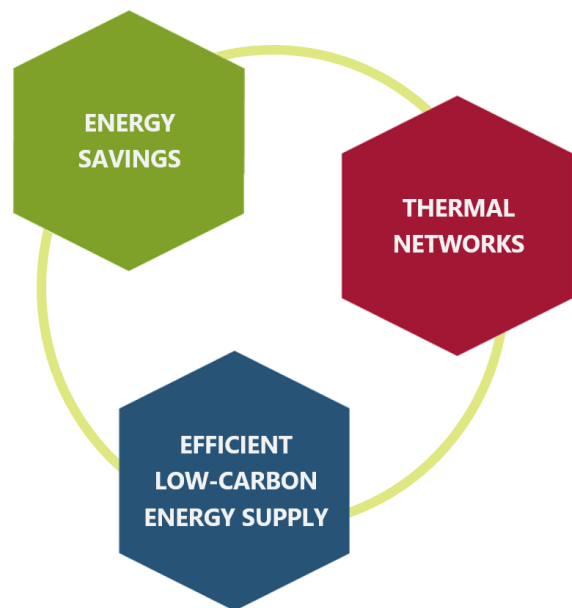
2.1. Three main pillars for decarbonising the H&C sector

The HRE4 project identifies three main “pillars” (i.e. focus areas), which are especially critical to address in order to facilitate the transition towards a future low carbon H&C system:

Energy savings	Thermal networks	Efficient low-carbon energy supply
<p>Heat savings can cost-effectively reduce the total heat demand in Europe by at least 30% [1]. Decarbonising the H&C sector requires energy efficiency on both the demand and supply sides of the sector, since they are each able to generate similar levels of savings in energy and CO₂. It should be noted that energy savings are appropriate to implement across all sectors, and can complement any H&C supply well, whether it is connected to a centralised thermal network or decentralised energy supplies.</p> <p>Target: <i>Improve energy efficiency both on the demand and supply sides of the H&C sector.</i></p>	<p>District heating (DH) can capture excess heat (e.g. from industrial facilities) and integrate renewable energy (RE) sources to replace fossil fuels. Currently there is more excess heat in Europe than all of the entire building stock heat demand. Cities can be supplied with 4th generation DH based on proven technologies (e.g. large heat pumps) to utilise such excess heat and/or RE sources. Additionally, heat synergy effects can be further magnified when combining DH and district cooling (DC) for improved whole-system efficiency.</p> <p>Target: <i>Increase the share of DH/DC considering its ability to facilitate the integration of different sectors, as well as utilising various excess/RE heat sources.</i></p>	<p>Individual heat pumps should supply the majority of the heat demand in lower heat-density areas (typically outside of the towns and cities) since they are able to effectively link relatively cheap RE electricity production (such as wind and solar) with efficient renewable heat production. Large heat pumps can be very effective in DH/DC systems where also their types of RE (e.g. geothermal or solar thermal) can be economically feasible.</p> <p>Target: <i>Deploy widespread use of heat pumps – large scale within DH/DC networks and individual ones outside of DH/DC areas, as well as RE sources where appropriate.</i></p>

Stakeholders are faced with several barriers standing in the way of realising the above-mentioned targets. However, across Europe, various activities are ongoing to address these barriers and many of them are completely replicable.

This report describes realised examples of how such barriers have already been addressed and overcome in practice and provide hints as to how these solutions can be readily replicated in other countries, including which countries seem to be in need of such solutions the most.



2.2. Barriers for the uptake of the HRE4 recommendations

The barriers identified here are all non-technical in nature. Some of the main ones are listed in section 0, where they are grouped within the three abovementioned pillars, for which there are three overarching categories: *Knowledge*, *economic* and *process*. The following icons are used to indicate the barrier categories:

- “?” for **knowledge barriers** relating to awareness, uncertainties, general information and/or technical details about the technology/solution;
- “€” for **economic barriers** i.e. pricing (OPEX and CAPEX), expenses, financing sources, investment types, feasibility, etc.;
- “→” for **process barriers** referring to relationships, interactions, process-specific, administrative and/or organisational challenges, including framework conditions (including political).

It should be noted that any given barrier does not necessarily relate exclusively to a single category where it is listed below – instead, the authors have sought to classify them only along their more dominant characteristics for the sake of readability. Likewise, most barriers are in one way or another applicable for multiple pillars, even if they have been worded here in a way that makes them primarily appropriate to only a single pillar. Finally, it should be noted that the examples listed in section 0 constitute a non-exhaustive list of barriers [2].

2.3. Examples of solutions

Each pair of the HRE4 recommendation and its barrier has been associated with an example mitigation measure (i.e. “solution”). If relevant, an existing business case was suggested that could be duplicated for other countries encountering the same barrier. These represent possible pathways that can be followed by market stakeholders in order to overcome obstacles for implementing the HRE4 recommended solutions.

2.4. Combining barriers and country-specific scenarios

The aim of this report is to outline the identified critical barriers for the market uptake of H&C technologies and measures determined in the HRE4, as well as recommended options how to overcome these. The solutions have been grouped according to the type of barrier and cross-referenced with the relevant recommendations from the HRE4 country roadmaps according to the 14 individual countries.

The barriers are evaluated for each country to determine a level of relevance and severity of an issue and scored with a grade between 1 and 3 in the following way:

- A score of **3** indicates that a barrier is a major issue in a country and should draw immediate attention (both the barrier and the linked HRE4 recommendations associated with it).
- A score of **2** means that the barrier applies, but not to the same extent as a score of 3.
- A barrier scored with **1** would suggest it is among the less relevant ones, and the country will most likely have other more crucial barriers to tackle as first priorities.

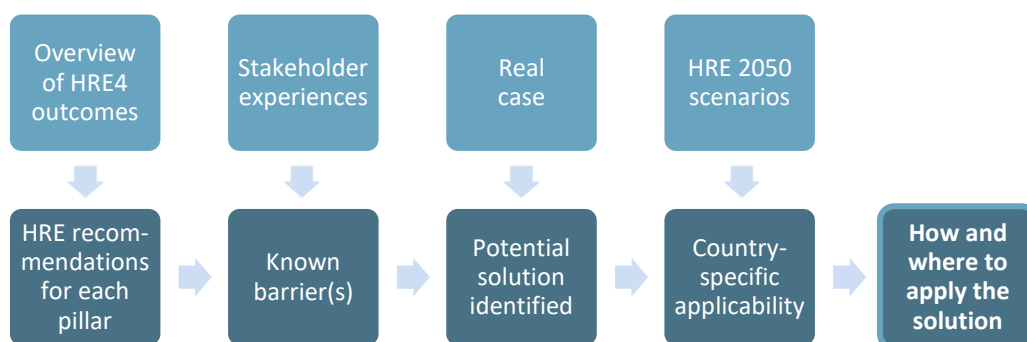


Figure 1. The methodology of identifying and applying business strategies.

For instance, a barrier involving inadequate knowledge on feasibility and suitable locations to apply district heating has been scored based on the increased proportion of DH supply between the current situation² and the HRE 2050. A barrier related to establishing DH will be most relevant in countries, where HRE 2050 identifies a need to increase DH's share of the total heat demand. The most extreme cases that anticipate to multiple the current DH capacity have been given score 3. If the future size of heat network needs to increase by no more than 100% then the countries has been given score 2. If the overall installed capacity in 2050 should actually be reduced (e.g. due to planned reduction of energy demand and increase of heat distribution efficiency), then this case was marked with 1.

² Referred to as baseline 2015 or "BL 2015" (as opposed to the baseline scenarios for 2050: "BL 2050").

3. Known barriers and identified solutions

The list of barriers describes the obstacles for implementing the suggested H&C solutions. These are split in the categories *knowledge*, *economic* and *process* barriers. It should be emphasised that the examples below constitute a non-exhaustive list of barriers and the proposed solutions should be used as suggestions. These barriers and solutions are then condensed into a few key strategies to follow for various technologies/applications in order to increase their market shares. Finally, the applicability of the barriers is checked for each of the 14 HRE4 countries.

Below is found condensed explanations of identified barriers and possible pathways for the various technologies/applications describing how they can increase overcome these.

3.1. Knowledge barriers [?]

- Building owners, and even architects, planners, contractors and installers, are often unaware or inexperienced in the use of (innovative) best practices suitable for their context.
- Though building owners are responsible for final decision-making, they are often unable to adequately evaluate different options, and instead have to rely on the architects'/contractors'/installers' suggestions (which do not always lead to the most cost-effective and/or low-carbon solutions).
- Use of life-cycle costing or other long-term decision-making tools are rarely used and the true costs of measures and resulting energy usage often remain unknown.
- Uncertainties and a gap between the perceived and actual energy savings cause building owners not only to have unrealistic expectations (e.g. overestimations) about individual measures, but also to underestimate the savings potential for comprehensive measures. This applies both at the end-user level and in terms of DH/DC utilities where to adequately size new energy generation units, it is essential to investigate the current and future energy demands. Inaccuracy in assessing H&C needs may incur additional investment costs when the demands are underestimated or may generate significant operational costs for those systems with overestimated H&C needs. The future demands are especially important as updated building efficiency regulation will have an impact not only on new buildings, but also on the renovation level of existing ones.
- Energy usage can essentially be considered as invisible, in particular for H&C. A lack of metering and visualisation devices and (typically) an annual billing routine make the consequences of energy use less obvious or concrete for building occupants.

3.2. Economic barriers [€]

- Energy prices do not adequately account for externalities (i.e. social and environmental costs), even when including energy/carbon taxes – therefore, decisions based on cost calculations from current energy prices do not reflect their true costs, both from an individual and societal perspective.
- Higher upfront cost require access to funding, making insufficient financial resources (upfront capital or financing) of end-users, particularly residential consumers, a barrier to faster deployment of H&C energy reduction measures.
- Upfront investment costs are sometimes given disproportionate weight in decision-making processes, leading to decisions that may actually be more costly in the long run when also considering other relevant costs (e.g. operations, maintenance, fuel prices, etc.) – this applies both at utility and end-user levels. In some cases, the use of higher than market average discount rates put a higher yet disproportionate weight on the investment.
- Most markets lack clear price signals incentivising energy demand/supply savings or alternative energy supplies to H&C systems.
- Local government budget constraints mean they often cannot invest adequately in large H&C projects, much less support their own citizens to do so.
- Many DH utilities face a shift from a previous (perhaps simpler) structure & price models whereby the “economy of scale” concept was sufficient to make DH both feasible and competitive. New consumer requests now tend to make it necessary to rethink production & distribution services (e.g. load patterns, etc.) and become more flexible³. In short, mature DH markets may face a future of “supplying less heat to more people” together with an increased focus on CAPEX-intensive costs (e.g. heat pumps or solar thermal collectors), as opposed to the previous focus on OPEX-focused costs (i.e. fuel). The main challenges arising for DH (and in some cases, also for DC) apply to three general circumstances:
 - In older inefficient networks, heat losses and water leakage can incur significant energetic losses and correspondingly higher costs. This also contributes to greater carbon emissions due to increasing energy production to balance losses and can result in a poor(er) reputation of district energy in general.
 - In mature markets, new relationships are becoming increasingly needed to take into account the (new) requirements of consumers:
 - “Prosumers” (excess heat, other sources)⁴.
 - Requirements for tailor-made solutions.
 - Transparent pricing.
 - Establishment of a “sustainability” brand.

³ Some challenges stated here have been identified in the referenced document [3].

⁴ The term “prosumer” is a contraction of the words “producer” and “consumer”. It reflects a consumer who (sometimes) produces more energy than what is consumed.

- Supporting consumers in becoming more energy efficient in their energy-related behaviour, the proper operation of H&C installations and the implementation of efficient building envelope measures.
- H&C flexibility services, production and/or consumption (e.g. storage options or agreements potentially disconnect consumers temporarily) should be rewarded financially as appropriate to help them become more feasible.

3.3. Process barriers [→]

- Split incentives abound, even within owner-occupied houses, meaning that goals and incentives are not always the same for those who invest in the measures and those who actually reap the benefits (e.g. sometimes the case with rental property).
- Involved parties often have a variety of motives for their own behaviour, and rarely do all these motives align to deliver the best energy performance.
- Most public procurement processes simply favour the lowest price, regardless of other conditions. In some countries, this ends up having a negative effect on the final energy efficiency or a choice to switch (or not) to alternative H&C systems.
- Many processes suffer from fragmented value chains, whereby multiple professionals' and/or companies' services are unaligned with each other, since they are involved in different stages or decision-processes.
- Decarbonisation requires efforts across all areas, and the structuring of this can be a complex and comprehensive process. For example, expanding DH/DC networks in large urban areas entails an intricate planning and environmental permission process dependent on existing utilities' infrastructure assets and the complexity of the system itself, which may integrate multiple low-carbon energy supplies. This, along with the willingness of customers to connect to the DH/DC, affects the duration and investment costs, and therefore how the comparison with alternative supply options may be conducted.

4. Pathways to overcome barriers

The proposed solutions below should be used as suggestions. These are then condensed into a few key strategies for various technologies/applications in order to increase their market shares. Finally, the applicability of the barriers is checked for each of the 14 HRE countries.

4.1. Identified solutions

In section 5, examples of cases are presented where several of the above-mentioned barriers have been overcome. Besides these descriptions, a list of recommended solutions across pillars and barrier categories is seen in the following.

4.1.1. Selling a service – not only components

A general trend of selling a service, not just a stand-alone technological product or measure, can engage those end-users who cannot or will not interest themselves in using/maintaining technologies/measures most efficiently. This approach provides an economic benefit with little or no initial costs, and can apply to all levels of liquidity:

- End-users with sufficient funds may find the return of investment relatively uninteresting compared to alternative investment options (with/without a relationship to the energy system).
- End-users with small amounts of available funds and/or low income may not have the ability to borrow the money to invest.
- End-users with an option to establish a loan to invest in renovations, heat pumps or other recommended measures may face costs of the loan which are too high to make it economically feasible for them and/or may consider accruing debt undesirable, no matter the reasoning. This can especially be the case with an outlook of only a small economic benefit to be gained several years in the future.

Energy saving agreements with mutual benefits for both, an energy service provider and a building's owner can be a potential solution to tackle extensive expenditures for renovations. Similarly, heat pump business models can be structured as though it were a DH/DC connection (i.e. it is the heat/cold that is sold, rather than the heat pump unit itself⁵). DH/DC companies could spread out the upfront connection fees across a period of several years in order to lower the initial cost burden on new consumers.

⁵ See section 5.3 for an example on how this has been realised.

4.1.2. Proactively engaging in local decarbonisation strategies

Businesses should proactively engage in strategic partnerships with local governments, particularly Signatories of the Covenant of Mayors for Climate and Energy⁶, to facilitate and enable the setting of stricter requirements both for the energy production as well as the demands in buildings and industrial processes. An example is found in the guidelines for local and regional policymakers “Energy system transition recommendations – the local approach” [4]. For utilities, it can prove to be an advantage to engage in the formulation and realisation of a local or regional decarbonisation strategy (e.g. for the municipality to reach net-zero emissions by year 2035). This can ensure that the utility will also play a role in the future decarbonised energy system and increase the security of supply by opening the market for locally based heat sources, thereby also lowering the uncertainty of future fuel prices and establishing a more stable framework for the business.

One of the initial steps in implementing the recommended solutions to a much greater extent is to identify the feasible locations for the new installations. In the investment planning process, energy companies can utilise relevant tools and data generated by HRE outlining the sustainable energy resources and providing an insight into the heating and cooling sector. A detailed spatial analysis will allow to understand the local nature of heating and cooling and more accurately appreciate infrastructure costs. A Pan-European Thermal Atlas (*Peta*) with hectare level mapping of thermal energy demands and resources is an example of some of the tools developed in HRE which is available online⁷.

4.1.3. Easily accessible overview of benefits and simple process for customers

Besides the need for an economic benefit, some residents see the possibility of an improved indoor environment as a key motivator. Similarly, publicly owned buildings can represent a relevant market for renovation measures, while the economic benefit is not the key issue, but instead the financing or administrative efforts required. Hence, it is important to pinpoint and highlight what motivates the different target groups and not focus on one parameter alone.

Companies in the energy business should prioritise the communication and raising the awareness among the building's owners regarding building performance measures. Communication to customers and engaging in a dialogue with them besides other affected citizens are key in all processes. Throughout the entire process of any project clients should be guided and provided with

⁶ www.eumayors.eu

⁷ The Pan-European Thermal Atlas (*Peta*) is available at the following link: heatroadmap.eu/peta4. Background information for the map can be found under heatroadmap.eu/project-reports.

easily-digestible information that facilitates the decision-making process and avoid that it becomes a (too) complicated and time-consuming experience.

4.1.4. Partnerships between businesses

Some companies engage in consortia by joining forces to provide a stronger combined “package” of product(s) and/or service(s). An example of this is described in section 5.1. In some cases, the consortia even educate their own craftsmen to address consumers in a given region. This requires high-level technical skills to ensure a smooth process and proper quality of the installations and makes a better control of the implementation and timelines possible.

In an integrated energy system with multiple stakeholder groups, new types of user-engagements and cross-sector interactions and transactions, technology providers and business models need to be open to connect to other technological components and more complex operation strategies. Partnerships between businesses can help them to prepare for this (ongoing) development, thus increasing their (combined) future competitiveness.

4.1.5. Improving the competitiveness of district energy

In terms of the competition with alternatives heat supply options (e.g. individual heat pumps) careful planning needs to take into account the local framework i.e. the actual costs for the available alternatives that consumers can choose from. The Peta can help identify where suitable areas are located. Renovating old DH/DC networks and/or converting them to integrate RE and excess heat are necessary steps for improving DH efficiency and feasibility.

Integrating thermal storage can cost-effectively be applied to facilitate the flexibility services requested from the non-dispatchable energy sources when the supply and demand profiles do not match.

In case of an existing DH solution, new price models may be needed when competing with alternative supply options. This could include having a price model reflecting the value of each customer (i.e. the cost for the utility) and provide an incentive for the consumer to optimise their heating system. Even though the consumer load profile affects the costs for the utility, the heat price in €/MWh is often (almost) equal for a large variety of consumes (with various load profiles). The most valuable customers for the utility may even have the strongest incentive to switch to an individual heat pump. To better align the cost for the consumer with the value/cost for the utility, a 3-way tariff structure could be applied with a mix of the following⁸:

⁸ Example provided by Profu, a Swedish independent consultancy and research company.

1. *Cost of energy (€/MWh)*: Variable costs (fuel and taxes) – possibly varying over the year.
2. *Cost of peak load (€/kW)*: Corresponding to the cost of investment in production and distribution capacity – based on measured peak load⁹.
3. *Cost of water flow through a consumer's heat exchanger (€/m³)*: Representing the cost of distributing the energy to the consumers. The flow indicates how well the consumer extracts H&C from the DH/DC network. A low flow reduces the water temperature more than a high flow, and a reduced return temperature makes the network more efficient. This is sometimes represented (also) by a penalty tariff applied if the return temperature is too high.

In many cases today, only tariff 1 and 3 above are used (together with a fixed cost).

Sensors in the network/at consumers to identify improvement possibilities will in general only represent a minor additional cost in "green field" projects but could turn out very valuable in the future (even if they are not needed on day one). Remote monitoring can make the utility able to focus on the consumers with the worst setup. Sometimes a visit to these buildings can help identifying the cause of a high return temperature and make it possible to improve the local *and* the overall system, thus reducing costs for both the consumer and the utility.

Similar to the abovementioned consumer requirements (and associated penalty for systems operated inefficiently), binding environmental goals for the system operator/utility together with a penalty if the goals are also possible.

4.1.6. Mitigating uncertainties of the future market by expansion of the thermal network

Utilities can ensure a minimum connection rate before cutting the first sod and should seek to develop strategic planning on how to extend their existing thermal networks and/or establish new ones – either separately or connected to the existing one(s). The mapping and processes explained in [4] ¹⁰ should be combined with the detailed knowledge of the existing network, which – together with evaluation of cost and benefits for increasing the network and production capacity if necessary – forms the basis of an analysis of where the potential new markets are located. With a carefully planned approach, the utility can engage in new areas without the risk of too low connection rate from the beginning. This can be done by combining a prepared overview of benefits for the consumers with an offer and associated contract which only comes into force if a sufficient number of consumers sign it before the construction of the network is begun¹¹.

⁹ Note that this requires a very reliable monitoring of each consumer, since their bill is in this case not only determined by an annual summary of the demand, but rather calls for continuous monitoring all year.

¹⁰ See section 5 in that report.

¹¹ This is further explained in [4].

4.2. Key business strategy recommendations

Based on the above-mentioned barriers and solutions, together with their applicability illustrated in Table 1, the following key strategies for increased market uptake can be derived.

1

Sell a service, not just a unit

Providing a service rather than merely selling a piece of technology or a renovation measure itself, can prove to be a business opportunity for companies related to energy-savings measures, H&C supply units and district energy by overcoming a main economic barrier, namely the large up-front investment costs (in order to achieve lower operation costs in the long term).

2

The keyword is “easy”

The companies selling the service/unit should make interaction with them as straightforward as possible. Customers with an initial interest in a given solution should easily locate the relevant companies. It should be simple for them to evaluate the benefits of the offered service/unit and the customers should be guided through the process in a clear manner – ideally by a single point of contact. Interactions should take up only a minimum of a customer’s time, so that it is not experienced as an administrative burden to engage/be engaged in the process.

3

Collaborate on a common decarbonisation strategy

By engaging in a common decarbonisation strategy together with local authorities and other stakeholders, relevant businesses can secure their role in the future decarbonised energy system and make sure that the process is structured across different stakeholder groups.

4

Engage in partnerships

Energy technology providers whose products and/or services are perhaps not economically feasible (enough) to be implemented as stand alone should be encouraged by the findings of HRE4 to explore the integration of other components or even cross-sectorial elements to develop a future-orientated business case.

4.3. Applicability in the 14 HRE4 countries

Using the methodology explained in section 2 the applicability of each barrier can be evaluated for each of the 14 countries. A complete overview of the scores can be found in Table 1 below. In Annex I is seen how the score was derived for each barrier in Table 1. The individual rating in scale 1 to 3 has been selected based on the level of the characteristics of the HRE 2050 scenario for the given country compared to the present (2015) situation – or in terms of policies compared to the baseline for 2050. Hence, the score does not reflect how often you presently encounter the stated barrier, but rather the risk of experiencing this kind of barrier during the energy system transition towards a decarbonisation. For each country this covers all barrier categories as well as the topics of energy savings, thermal network development and low carbon technology dissemination. From this, the following trends can be seen:

- Lack of awareness on the best practice and most efficient solutions particularly in regards with the energy saving is a barrier relevant for all the HRE4 countries, though particularly in countries such as Czech Republic, France, Germany, Hungary, Poland and Romania where HRE4 identifies the strongest need for savings.
- Inadequate understanding and use of existing resources and suitable locations for distributed low-carbon technologies is a main issue which applies to all HRE countries.
- The reluctance of national authorities to increase energy savings and low-carbon energy supply targets matching the EU ambition level for 2050 has been identified for all countries and all pillars.
- The issue of energy efficiency, low-carbon supply and/or district energy requiring large upfront capital applies in general to all countries and across all pillars. However, countries which already have a suitable level of DH will not experience the engaging of new DH consumers to the same extent as “newcomer countries”.
- Fragmented construction value chains can make any renovation or installation process complex and disruptive. This applies to most of the countries. In terms of connecting new consumers to DH, experienced countries with a well-developed DH market would encounter such barriers more seldom. However, in these countries, challenges of increased competition with alternatives and new requests from consumers can arise, thus making the utilities face other barriers instead.

Category	Barrier	1	Solution	Austria	Belgium	Czech Rep.	Finland	France	Germany	Hungary	Italy	Netherlands	Poland	Romania	Spain	Sweden	UK
		Minor relevance /Not applicable															
		2															
		2	Very relevant														
? ₁	Lack of awareness of best practice for building performance measures.			2	2	3	2	3	3	3	2	2	3	3	2	2	2
? ₂	Miscommunication and a lack of integrity between the energy sector stakeholders and final customers.			2	3	3	1	3	3	2	3	3	2	1	3	1	3
? ₃	Inadequate understanding and use of existing resources and locations for low-carbon H&C sources.			3	3	3	3	3	3	3	3	3	3	3	3	2	3
? ₄	Inadequate knowledge on the feasibility and suitable locations to apply district energy.			2	3	3	1	3	3	2	3	3	2	1	3	1	3
€ ₁	High investment costs in energy savings measures for end-users.			2	2	3	2	3	3	3	2	2	3	3	2	2	2
€ ₂	High investment costs in low-carbon energy supply for end-users.			3	3	3	3	3	3	3	3	3	3	3	3	2	3
€ ₃	High investment costs for connecting to a thermal grid for end-users.			2	3	3	1	3	3	2	3	3	2	1	3	1	3
€ ₄	High disproportion between peak and base heat demand, resulting in (increased costs of) supply capacity units with fewer full-load hours.			2	2	3	2	3	3	3	2	2	3	3	2	2	2

Table 1 (part 1). Barrier assessment table. (See also next page.)

Category	Barrier	1	Minor relevance /Not applicable	Solution	Austria	Belgium	Czech Rep.	Finland	France	Germany	Hungary	Italy	Netherlands	Poland	Romania	Spain	Sweden	UK
		2	Relevant															
		2	Very relevant															
→ 1	Reluctance of national/regional/local authorities to pursue ambitious energy savings targets while underestimating the needs for energy savings to decarbonise the energy system.			Businesses can engage in strategic partnerships with local governments to set stricter requirements for the demands in buildings and industrial processes. See example in [4].	3	3	3	2	3	3	3	3	3	3	3	3	2	2
→ 2	Reluctance of national/regional/local authorities to pursue ambitious energy/climate targets, while underestimating the future needs for efficient low-carbon energy capacity.			Businesses can engage in strategic partnerships with local governments to set stricter requirements for the energy production. See example in [4].	3	3	3	3	3	3	3	3	3	3	3	3	3	3
→ 3	Reluctance of national/regional/local authorities to pursue ambitious energy/climate targets and underestimation of the possibilities that district energy holds.			Businesses can engage in strategic partnerships with local governments to facilitate DH network development with enabling legislation and urban-planning instruments. More info in case 5.2 and in [4].	3	3	3	2	3	3	3	3	3	3	3	3	2	3
→ 4	Fragmented construction value chains, making the energy-saving (e.g. renovation) processes complex and disruptive to customers.			Improving the communication between stakeholders and educating craftsmen and end-consumers. Facilitate the process for the consumer. See the case described in section 5.1.	2	2	3	2	3	3	3	2	2	3	3	2	2	2
→ 5	Fragmented construction value chains, making the implementation process of low-carbon individual H&C supply complex and disruptive to customers.			Improving the communication between stakeholders and educating craftsmen and end-consumers. Facilitate the process for the consumer. See the case in section 5.1 (applies though renovation related).	3	3	3	3	3	3	3	3	3	3	3	3	2	3
→ 6	Fragmented construction value chains making the implementation process of DH/DC systems complex and disruptive to customers.			Improving the communication between stakeholders and educating craftsmen and end-consumers. Facilitate the process for the consumer. See the case in section 5.1 (applies though renovation related).	2	3	3	1	3	3	2	3	3	2	1	3	1	3

Table 1 (part 2). Barrier assessment table. (See also previous page.)

5. Case descriptions – examples of how barriers have been tackled

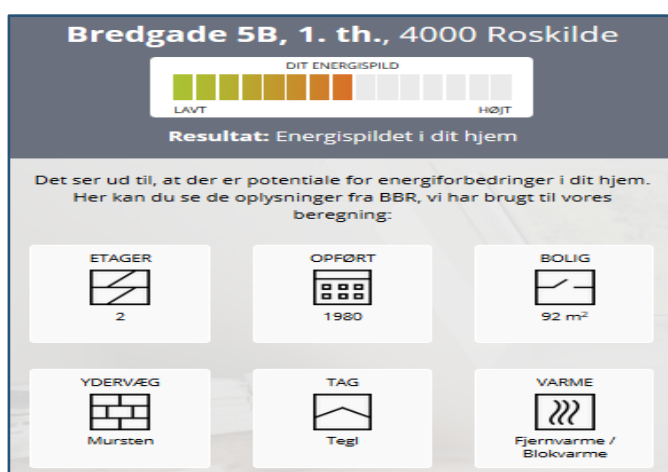
Five cases are described below, each addressing some of the challenges described above, and all having their own high replicability potential. The following points are included for all:

- Quick project facts as an introduction
- General description of the case
- Business model/strategy
- Motivation for involved stakeholders
- Barriers addressed
- Replicability potential
- Links to further information

5.1. Activating a slumbering demand for deep energy renovations

One-stop-shop model supplying a deep energy renovation package

- Location: many localities nationwide across **Sweden** and **Denmark**
- Pillar(s) addressed: **Heat savings**, though possibly applicable to other pillars as well
- Barriers addressed: *Knowledge* and *process*
 - ? Lack of awareness of best practice for building performance measures
 - → Fragmented construction value chains making the renovation process complex and disruptive to customers.
- Stakeholders involved: Industry, SMEs, financial institutions, local authorities, local professionals (e.g. installers, architects and engineers) and end-consumers



The address is indicated at the very top and a coloured scale shows a quick rating from low to high of "the energy waste of your home".

The six boxes at the bottom indicate the number of floors, year of construction, living area, outer wall type (e.g. bricks), roof type (e.g. tile) and heating solution (e.g. DH/block heating).

Figure 2. Screenshot from the BetterHome website (here in a Danish version – see translation in the sidebox) for a sample address and a preliminary estimation of the energy waste in the house, on a scale from low to high. This information is based on a nationwide database of building properties. [5]

5.1.1. General case description

BetterHome is a one-stop-shop solution coming entirely from a commercial initiative. Four major Danish building manufacturers, *Danfoss* (building technologies and appliances), *Velux* (windows), *Rockwool* (insulation) and *Grundfos* (system pumps) have initiated the model together. The four companies join forces with (local) building professionals (installers, engineers and architects), as well as with financial institutions, utilities and local governments, in order to offer a comprehensive renovation package to the customer. The model applies a holistic approach, which requires the active involvement from most stakeholders on the renovation market. *BetterHome*'s services are available to customers in both Sweden and Denmark. The consortium is expanding its market quickly and already manages around 200 renovation projects per year, mostly single-family houses in Denmark, with just a relatively recent launch in Sweden. The majority of these projects are considered to be 'deep' renovations resulting in energy savings of 50-70%.

The model activates a demand for energy renovations in the residential sector by guiding the building owner through the entire renovation process. These well-known brands, and their thorough training of (local) installers, ensure a high quality of the result. By doing the renovations in such a manner, strong trust in the process is built. *BetterHome* is essentially reconstructing the renovation process, reducing fragmentation of the supply-side and mismatched expectations of the final result. The model's success can be explained by the training of its installers and an innovative online application, guiding the installer throughout the whole process, while also ensuring a smooth experience for the building owner.

5.1.2. Business model/strategy

To boost demand for renovation, the model combines other incentives (such as comfort, aesthetics, value of the building etc.) with energy measures. Installers are trained to build a positive and trustworthy relationship with customers, as well as to increase their awareness of the multiple benefits of energy renovations. By highlighting other aspects (i.e. having a comfortable and healthy home) instead of only the potential energy savings (which is often a somewhat-abstract concept for building owners to grasp), building renovations can appeal better to residents' more immediate concerns. Therefore, it could have a greater potential to actually compete with other types of investments (such as a family vacation or a new car) which residents often prioritise over energy measures.

The model is designed to handle two of the largest barriers to investments in energy renovation: awareness and trust in the construction sector. Though many Europeans, especially across Scandinavia, tend in general to be aware of the importance of reducing their own climate impact, few fully understand the role their building plays in this, and even less so about which measures

should be implemented. The *BetterHome* model helps remove all such intermediaries and minimise the burden on building owners.

5.1.3. Motivation for stakeholders

The *BetterHome* one-stop-shop model is seen as an effective tool to increase demand for deep (energy) renovations, which increases the market share and revenues for the industry partners, as well as to the small/local businesses (engineers, architects, installers) and financial institutions involved in the process.

A boost in deep energy renovations is a win-win-win situation, for the economy, the environment and the people:

- A clear economic interest exists not only from the industry and SMEs, but also from politicians, to see an increase in energy renovations. Even though some companies cover more than one country (as in this case), the type of model used here also engages local professionals, thereby creating local jobs (often a focal point for local authorities), while contributing to speeding up the economy in general.
- A thorough decarbonisation of the building sector requires that renovations are deeper and proceed at a faster rate in order to make significant environmental impacts, which are of course instrumental to meet EU and national climate and energy targets, as well as those contributions made at local and regional scales.
- There is also a social component tied to this model. With a high share of energy poverty and health issues related to poor indoor air quality, deep renovations can both reduce energy bills and create healthier living environments for residents.

5.1.4. Addressing the barriers

5.1.4.1. Knowledge barrier: Lack of awareness of best practice for building performance measures.

Home owners are responsible for the decision-making regarding building performance measures. Building owners may in general receive a lot of advice and information (not all of which is accurate or suitable for their specific building), leading to difficulties in evaluating alternatives. Therefore, they often have no other choice than to rely on the suggestions from contractors and other craftsmen, which has a risk to be one-sided and/or inadequate, increasing uncertainty and lowering the overall trust in renovation works and energy efficiency.

BetterHome guides building owners through the whole renovation process, reducing the uncertainty-threshold to invest. The owner can simply insert their own building information onto the website and retrieve an estimation of energy-saving potential, possible measures and a cost estimate. This

information is later confirmed and adjusted after a house visit by a *BetterHome*-trained professional. The model gathers together all relevant information and packages it nicely as an appealing package for building owners.

Building performance may be too complicated for building owners to know what to expect, which lowers their willingness to invest. The *BetterHome* model guides the customer throughout the entire process and provides them with easily-digestible information that enables an easier decision-making process. Furthermore, *BetterHome* is funded by four well-known building manufacturers. This lowers uncertainty about the quality of not just the products, but the whole process. In short, *BetterHome* reduces uncertainties for the building owner through tailored advice.

5.1.4.2. Process barrier: Fragmented construction value chains making the renovation process complex and disruptive to customers.

Fragmented construction value chains with multiple professionals involved at various stages, often working on different timeframes or even at cross-purposes, typically characterize most renovations. The renovation market is supply-driven, which can lead to a mismatch between the offered products and the end-users' needs. Many customers see high operating costs or a poor living environment as an acceptable alternative to a time-consuming, disruptive and risky renovation process. Too many interests and actors tend to make the process overly complex and time-consuming for building owners.

The *BetterHome* model creates a lean process by harmonising the multiple actors and activities, resulting in a better process to the customer. Building owners only have a single contact point for the whole renovation and do not have to worry about the process' effectiveness. The threshold to invest is reduced by making it simpler for customers.

The model also structures the renovation process for installers, including guidance, training, support and clear deadlines. The online application minimises extra work for installers, helping them to plan their work. What the installer is expected to do in each of the five steps (illustrated below), are clearly outlined, from the approach in the first call to the finalization of the project.

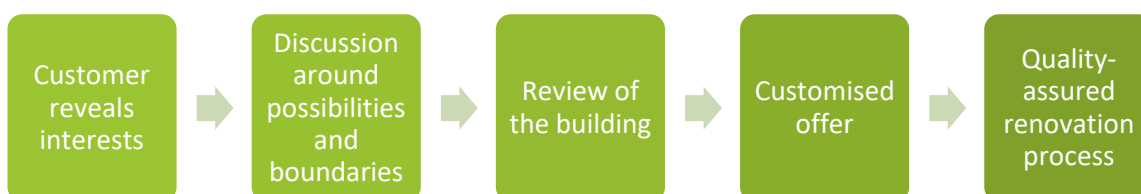


Figure 3. The five steps of *BetterHome*'s "renovation journey" as a full service offered.

5.1.5. Replicability

The model can be replicated in other countries if a similar group of companies are able to work together, supplying the model to the local market. Besides this, the *BetterHome* consortium may be interested in expanding their own markets to other countries as well, since they are each already represented on the international market separately. The *BetterHome* organisation may also choose to incorporate additional local brands in order to make inroads into new markets.

One example of a similar setup exists in Ireland where the *SuperHomes* scheme enables homeowners to implement all the cost-effective and sensible energy measures including insulation, air tightness and advanced ventilation while heating and hot water can be provided by renewable energy technologies such as solar photovoltaic panels and heat pumps. A “SuperHomesAdvisor” (*SuperHomes* employee) will survey the home and identify all measures needed for a complete overhaul, and the process of planning and installation will be supported by *SuperHomes*.

Furthermore, it should be noted that the core model (i.e. gathering strong market players to work together with local professionals in supplying a complete, easily-accessible/comprehensible package for customers) is hardly a model that must remain limited only to building renovation measures. A similar strategy could be applied to any of HRE4’s three pillars described in section 2, or even crossing pillars for that matter.

5.1.6. Further information

- www.betterhome.se / betterhome.today
- guarantee-project.eu
- superhomes.ie

5.2. Creating synergies across a large urban region

Expanding and interconnecting DH networks, and combining it with DC

- Location: **Milan, Italy**
- Pillar(s) addressed: **Efficient low-carbon energy supply, thermal networks**
- Barriers addressed: *Knowledge and process*
 - ? Miscommunication and lack of integrity between energy sector stakeholders and final customers.
 - → Complex urban-planning process and social awareness in DH development/expansion.
- Stakeholders involved: Local authority, local energy utility and end-consumers



Figure 4. Interconnection status and plans for the different networks in Milan. [6]

5.2.1. General description

Milan is faced with a high number of polluting diesel-fuelled boilers used for all kinds of heating purposes (residential, tertiary and industrial). To combat this, Milan and the local electricity and gas utility company A2A have invested in CHP for DH, and partly also for cooling. Additionally, there are investments to recover the heat from an incineration plant ("Silla 2" in Figure 4) and that of an aquifer thermal energy storage (ATES) combined with a 15 MW heat pump.

After a period of great expansion, the city is now connecting its major DH networks together to increase their flexibility. Besides this, an expansion of the 11 km district DC network is also planned. All these objectives are part of the city's emissions reduction plan and are integrated into their Sustainable Energy Action Plan (SEAP) as well as in its general urban planning. In 2014, the DH network consisted of 136 km of pipes providing about 714 GWh of heat, and 3.5 GWh of cooling power. The goal is to reduce emissions to 20% below 2005 levels by 2020, when the DH network is supposed to serve even more demand (1180 GWh heat per year). The main DH networks and associated supply in the city are the following (see also Figure 4):

- The *Gallaratese/San Siro* network is powered by the *Silla 2* waste-incineration plant, and the *Milano Sud* network is powered by a CHP and groundwater *Famagosta* heat pump plant. These two grids were connected in December 2014, extending the outreach of the network over the whole western area of the city, and enabling a more efficient use of the heat produced by *Silla 2*.

- The *Città studi/Tribunale* district is powered by the *Canavese* plant, which is a combined CHP and heat pump plant, and the *Santa Giulia/Mecenate* area is powered by the CHP plant *Linate*. These two grids have been connected since January 2015, forming a large DH network serving the eastern part of Milan.
- The *Bicocca* district is powered by the *Tecnocity* plant and consists of a CCHP (trigeneration) plant that also provides heat for certain suburbs bordering the northern part of Milan.

By connecting its DH networks, the required total peak load capacity has been reduced and allowed it to introduce new features. One example of such a solution in Milan is the divestment of 6 gas engines with a total capacity of 18 MW and the subsequent entry into operation of a heat exchanger to recover excess heat from a nearby glassware production facility of 5 MW.

5.2.2. Business model/strategy

With A2A as investor, the installation of the plants and the grid does not imply any major costs for the city – except staff time to collaborate on ad hoc activities with the utility, help citizens and facilitate the process in general. This way, the model makes the uptake of DHC possible without significant monetary investment for the local government. The local authority grants concessions to A2A every year for the underground use, thereby also creating a revenue stream for the city.

With the high heat-demand density and various energy sources available, the cost of DHC for customers can be kept competitive in comparison to alternative technologies, while still being profitable for A2A. As in most other DH systems, the customers pay a connection fee to join the DH network, in addition to rates for the energy consumed. This varies according to the location and the size of the household. A high acceptance and satisfaction among citizens are ensured through continuous quality controls, information-sharing and public consultations.

5.2.3. Motivation for stakeholders

The city achieves cleaner air for its inhabitants and complies with its environmental commitments by facilitating further development of DHC through close collaboration with the A2A and providing urban planning with a focus on measures to reduce GHG emissions.

The local utility has found a business model where they are able to attract customers to achieve enough income to counterbalance the large investments required (about 200 million EUR spent by A2A during 2008-2013 just for expanding and linking the networks).

While the offered solution cannot be much more expensive than an existing solution for the customers, significant non-economic arguments are also present, such as contributing to cleaner air/less GHG emissions, avoiding maintenance costs on their heating/cooling system (since this is now provided by A2A) or reduced risk of fires in the buildings (from since-removed boilers).

5.2.4. Addressing the barriers

5.2.4.1. Knowledge barrier: Miscommunication, lack of integrity between the energy sector stakeholders and final customers.

Citizens may be uncertain about the benefits of the different available energy solutions – or even their existence/possibilities. The city has invested in awareness-raising activities through the creation of an energy help desk (*Sportello Energia*) [7] where citizens can get free advice on different energy-saving solutions including DH. Furthermore, A2A's website publishes regular updates on the DH network development to keep residents informed. Also, the website hosts a "direct line" section, which allows current and potential DH customers to ask questions about contractual terms and conditions and receive technical support online.

5.2.4.2. Process barrier: Complex urban-planning process and social awareness in DH development/expansion.

The municipality has supported DH network development with enabling legislation and urban-planning instruments and has guaranteed this political commitment by signing the Covenant of Mayors (2008) and Compact of Mayors (2015), giving DH a strategic importance in its broader CO₂ reduction targets. As an example of facilitating the process, the city has created a shared database to integrate the various public construction, including DH development, so that different infrastructure providers can work simultaneously, and inconveniences related to traffic, noise, pollution, etc. can be kept at a minimum. Since all types of construction work disturb everyday life, especially if citizens are unprepared for the upcoming changes, A2A also sends out letters two weeks in advance to building administrators whose blocks will be affected, so that they and their occupants are aware of the potential inconveniences and can plan their own activities accordingly.

5.2.5. Replicability

The awareness-raising campaign carried out by the municipality and A2A has been very successful in making citizens understand the benefits linked to DH and has streamlined its uptake. DH through CHP or recovered excess heat is an already available, well-known and efficient technology. This means that the challenges are more linked to processes than the technology itself. A good collaboration between the utility and local government has resulted in a positive feedback loop facilitating awareness and a positive impression of the technologies in the public eye, thus making expansions much more palatable to citizens and easier to implement, thereby creating even more flexible DH solutions. For these reasons, this case likely has a high replication potential, though it should be highlighted that a sufficient building density and/or existing, exploitable heat sources should be present to attain such heat synergies, while a solid interface between urban planners and local energy providers is crucial as well.

DC can further increase whole-system efficiency, reduce electricity peaks in the summer and thereby further reduce GHG emissions. This is particularly applicable to new residential and tertiary buildings, though it is not as easy to apply in existing housing stock, because they normally do not have a centralised ventilation system.

5.2.6. Further information

- A2A's activities in Milan,
www.a2acaloreservizi.eu/home/cms/a2a_caloreservizi/impianti_reti/area_milano
- Heat Roadmap Europe tool to identify high-demand density areas and potential sources, Peta4¹²,
heatroadmap.eu/peta4

5.3. Fast track heat pump roll-out

Heat pumps installed without high investment costs for the consumer

- Location: **Hylke**, near Skanderborg, **Denmark**
- Pillar(s) addressed: **Efficient low-carbon energy supply**
- Barriers addressed: *Knowledge and economic*
 - ? Miscommunication, lack of integrity between the energy sector stakeholders and final consumers.
 - € Upfront investment cost of standalone heat pumps.
- Stakeholders involved: Local authority, energy-service provider and end-consumers



Figure 5. Picture from the school in Hylke. [8]

¹² The Peta4 maps contain modelled heat demand at a 100 by 100 m resolution. Amongst other features, it includes layers showing those city areas where DH systems do and could potentially exist, which can be spatially compared to a database of identified sources of excess heat supply.

5.3.1. General description

Best Green installs and maintains heat pumps for its consumer-clients, thereby selling heat as a service, instead of selling them the heat pump itself. The case of Hylke includes 11 clients ranging from public buildings, to private households and business. The setup is somewhat similar to a DH solution, where the customer pays a one-time connection fee (relatively small compared to the costs typical for a complete heat pump investment) and afterwards pays a mix of a fixed annual fee and for the heat actually used.

The electricity used in public and commercial buildings is certified wind power and the project has phased out approximately 30% of the oil consumption in Hylke and in nearby areas, which have no access to DH.

All installations are Smart Grid ready. For all installations, the electricity consumption and heat production are measured and logged every 5 minutes. In the self-developed software, the data is recorded in order to monitor the performance of the heat pump (COP). This procedure enables *Best Green* to react immediately if one of the heat pumps does not perform as expected.

All installations are air-to-water heat pumps mono-block unit (*Stiebel Eltron* and *Nibe*):

- A school is equipped with a *StiebelEltronWPL23E* cascade system. The heat pump system has, after its first year in operation, covered the school's entire heating demand, with a measured COP of 3.2.
- A nearby golf club and supermarket have each installed a *NibeF2300-20* unit. The supermarket uses the excess heat from an existing cooling installation, thus reaching a COP of 3.3.
- Eight private households have installed *NibeF2040-8/12* systems, reaching a COP of 3.0.

5.3.2. Business model/strategy

The business model focuses on continuous income from their customers rather than a one-time profit. In case consumers choose to disconnect, the used heat pump can be installed elsewhere, thus minimising the costs for *Best Green*. The general and replicable business strategy is to move the focus from only one-time sales to include subscriptions, that is from selling products (including installations) to a continuous income from varied, long-term and attractive services.

Similar approaches could especially be relevant for saturated markets, such as where heat pumps could still increase their business activities by supplying the (mandatory) service check of heat pumps rather than focusing only on selling and installing the heat pumps.

5.3.3. Motivation for stakeholders

The implemented solution has enabled private and public consumers to save money on heating while reducing CO₂, without having to carry the investment cost burden of their own heat pump installation. In addition, it has helped local communities to stay “green” through the implementation of innovative and effective heating solutions in public, private, industrial and commercial buildings.

The town of Hylke has gained savings of more than 20,000 EUR on its annual heating bill while reducing CO₂ emissions by 100 t yearly. The school alone saves 10,000 EUR per year. To ensure the community’s involvement, an info-screen was placed in the school’s common area to continuously display updates about heat consumption, indoor climate and the environmental impact of the school.

5.3.4. Addressing the barriers

5.3.4.1. Knowledge barrier: Miscommunication, lack of integrity between the energy sector stakeholders and final customers.

The municipality supported the roll-out of the solution with an awareness-raising campaign (e.g. the info-screen in the public area of the school), but the best communication impact has been through the private customers themselves further promoting this solution in their own neighbourhood. It has been similarly shown in many other cases that word-of-mouth among peers and neighbours is one of the most effective ways to promote a good solution, although it is also just as effective in blocking a (perceived) poor solution.

5.3.4.2. Economic barrier: Upfront investment cost of standalone heat pumps.

The *Best Green* solution addresses the two primary barriers related to investments in new green heating installations: initial investments and operating expenses. *Best Green* sizes up, finances, owns and operates the heat pump facilities and infrastructure. The building owner owns and accounts for the part of the installation inside the building, which covers the storage tank, central heating system, thermostat, etc. Furthermore, the building owner pays a fixed price for the heat (per MWh) and a yearly fee covering maintenance and service of the heat pump.

5.3.5. Replicability

This solution is fully applicable within (and outside) other towns and cities with no DH, where the aim is to ensure the utilisation of RE electricity through flexible electricity consumption. By mid-2017, *Best Green* had, for example, applied this same solution to 13 different schools.

With the aim of reducing GHG emissions and especially phasing out oil boilers, the *Danish Energy Agency* has decided to promote this solution’s roll-out. More companies providing a similar service

have been invited to join this market (to increase the deployment speed) and a similar setup has been launched for larger heat pumps targeting industries. This is done by supporting a fraction of the heat pump investment for the companies' first clients in a start-up phase (maximum of approximately 2,700 EUR and 13,400 EUR respectively, gradually reduced once the number of clients increase). However, the solution has already shown to be sustainable for *Best Green*. The *Danish Energy Agency* scheme is an attempt to boost the market and speed up deployment (by introducing more players in the market¹³ and initiating the separate "industry version").

Since the first days of the *Best Green* solution, several DH utilities have used a similar approach to reach consumers outside their network. Such utilities already have the administrative setup (accounting, billing etc.) and financial strength to offer this service too. Besides this, their brand strengthens the terminology that the solution resembles DH supply. In other words, it may seem more trustworthy for some consumer if a big utility offers the solution rather than a (to them perhaps) unknown company.

The model is not linked to specific barriers/framework conditions in the country and should therefore also be applicable outside Denmark.

5.3.6. Further information

- www.bestgreen.dk (in Danish)
- How to implement the business model, described above (in Danish):
ens.dk/sites/ens.dk/files/Energibesparelser/drejbog_til_implemtering_af_forretningsmodel_til_salg_af_varme_fra_individuelle_varmepumper.pdf

5.4. Energy saving partnerships

Shared energy-performance contracting as a budget-neutral approach to improve buildings, reduce energy/water use and increase operational efficiency

- Location: **Berlin, Germany**
- Pillar(s) addressed: **Heat savings**, though possibly applicable to other pillars
- Barriers addressed: *Knowledge* and *economic*
 - ? Lack of awareness of best practice for building performance measures.
 - € Insufficient resources of end-user.
- Stakeholders involved: Financial institutions, ESCO (energy service company) and local authorities

¹³ The 5 companies are *Best Green*, *Greentech Advisor A/S*, *OK a.m.b.a.*, *SustainSolutions* and *Verdo Go Green*.

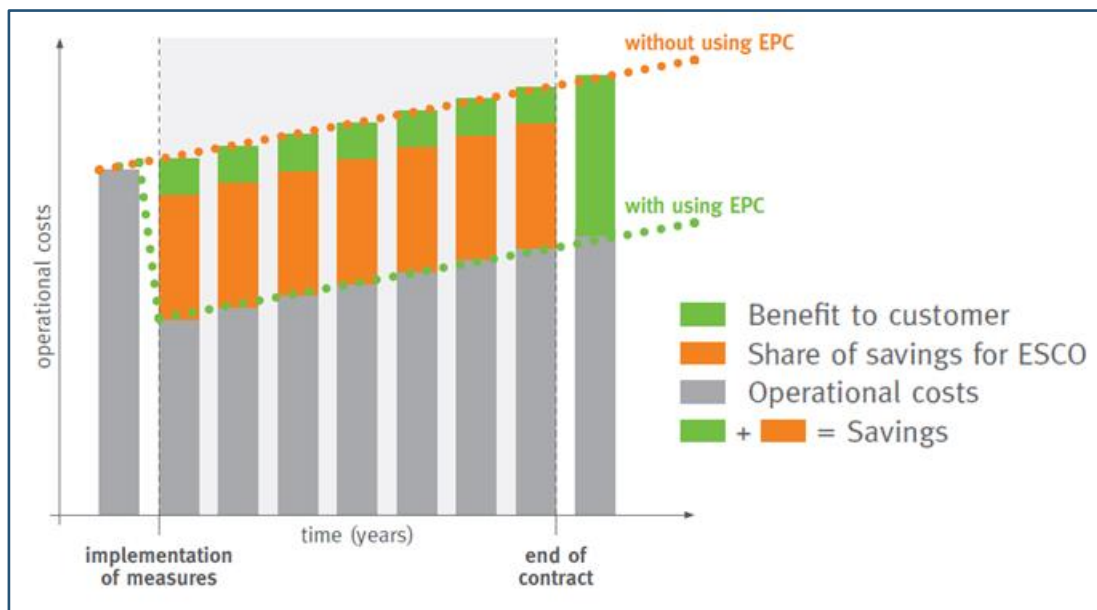


Figure 6. Indication of how the savings created can already benefit the customer as soon as the shared Energy Performance Contract (EPC) is signed with the ESCO. [9]

5.4.1. General description

The *Energy Saving Partnerships (ESP)*, developed by the *Berliner Energieagentur* and *Berlin's Senate Department for Urban Development*, is an ESCO making use of an alternative model for Energy Performance Contracting (EPC). The *ESP* in Berlin aims to renovate the city's public buildings. While typical ESCOs make the necessary investment upfront and take the full financial risk, and then are re-financed through all the savings in energy costs for a certain time period, the ESCO only takes a majority of the cost-savings, over a bit longer time period.

Their cost savings are shared between both the ESCO and the building owner. This way, the building owner derives profits, and so does the ESCO. As project manager, the *Berliner Energieagentur* has successfully launched and accompanied 25 *ESPs* with 1,300 public buildings and more than 500 properties in Berlin alone since 1996.

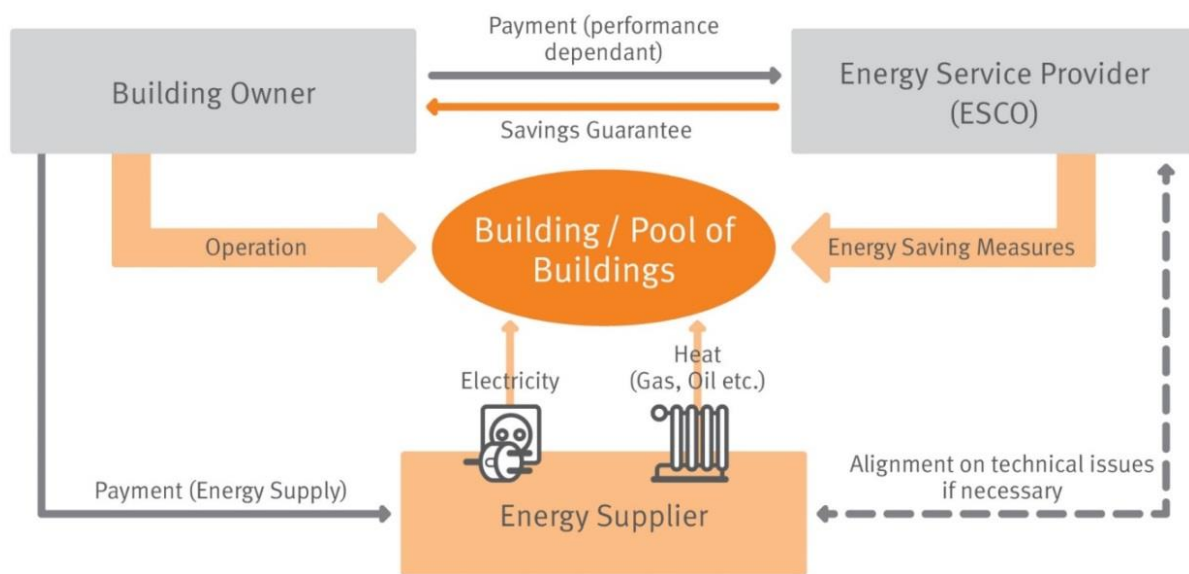


Figure 7. Principle sketch of the EPC setup. [9]

5.4.2. Business model/strategy

From the ESCO's point of view, the strategy is to share part of their revenue with the clients, thereby attracting more customers – they are essentially making an "investment" in order to increase their market share. Their solution differs from many EPCs, where the owners often only reap benefits at the end since the ESCO recoups all "profits" for its own expenses first and foremost. Despite the slightly longer contracts, the *ESP's* sharing principle ought to be more appealing to owners who will be offered an immediate benefit, instead of having to wait for their reward. However, also an option of a shorter contract period is possible from the *ESP*, thus applying all savings to the ESCO, but in a shorter timeframe before the building owner can retrieve all savings onwards.

5.4.3. Motivation for stakeholders

An economic benefit is achieved for the building owner from year one. Financial institutions gain additional loans/partnerships. Authorities need to increase the renovation rate to meet energy and climate targets. Increasing investments in energy efficiency also generates local jobs and possibly boosts the overall local economy.

5.4.4. Addressing the barriers

5.4.4.1. Knowledge barrier: Lack of awareness of best practice for building performance measures.

Building performance can be a complicated field, even for the experts. In many cases, building owners have unrealistic expectations about individual measures and underestimate the potential savings from more comprehensive measures (i.e. deep renovation). Questions about best practices for a specific context or building regulations often discourage building owners from pursuing energy efficiency themselves. With this model, the building owner is provided with an overview and guarantee of the economic savings as part of the EPC, thus avoiding the uncertainty if a renovation will cut the energy bill by an expected amount.

5.4.4.2. Economic barrier: Insufficient resources of end-user.

A large upfront cost for energy efficiency investments is often mentioned as one of the biggest barriers. Compared to investing in the energy-savings measures, the building owner in this case is ensured an energy reduction by the ESCO paying for the renovation and is compensated by a part of the savings in a specified period of time.

5.4.5. Replicability

The model is not limited to Berlin or Germany, and since it is not restricted to specific framework conditions, it should be replicable in other countries as well. It has already proven to be replicable due to a high number of examples, as mentioned in section 5.4.1, and has already been a success in Leipzig (Germany) and Vienna (Austria). These cities are supporting *ESPs* from concept-planning of projects to the realisation of energy-saving guarantee contracts that have already been tested in practice.

The solution in this case differs from traditional EPCs, where a benefit for the building owner is only achieved at the end of the contract. A mix of these is also possible, as seen in the case winning the 2017 *European Energy Service Award (EESA)* in the category of *Best Energy Service Project*¹⁴. Here the calculated savings are fully paid to the ESCO, thus leaving the building owner with an unchanged bill for the first ten years. However, if the actual savings are larger than what was expected, the ESCO and the building owner share the profits, whereas, if they are smaller, the ESCO is not compensated at all. [10]

¹⁴ EPC project by *Siemens*, guarantee-project.eu/eesa-2017-in-pictures/winners-2017.

Several EU funds support initiatives like this, such as the *Structural Fund (ERDF)* and the *European Fund for Strategic Investment (EFSI)*.

5.4.6. Further information

- *Berliner Energieagentur, Energy Performance Contracting:*
www.berliner-e-agentur.de/en/topics/energy-performance-contracting
- *ERDF:* ec.europa.eu/regional_policy/en/funding/erdf
- *EFSI:* www.eib.org/efsi / ec.europa.eu/growth/industry/innovation/funding/efsi_en

EPC market in Europe: www.transparensen.eu/eu/home/welcome-to-transparensen-project

5.5. Combining data and heat

Utilising excess heat for district heating

- Location: **Mäntsälä, Finland**
- Pillar(s) addressed: **Efficient low-carbon energy supply**
- Barriers addressed: *Process*
 - → Trust, and the ability to seek an agreement between involved stakeholders.
- Stakeholders involved: Industry and energy-related business professionals (e.g. local energy company, heat pump manufacturer and DH company).

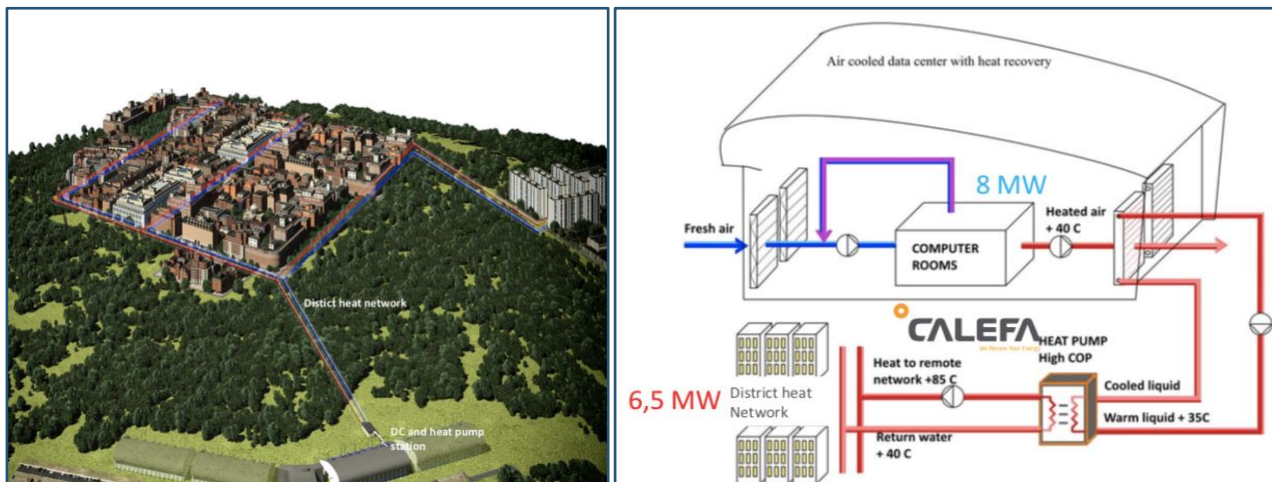


Figure 8. Map of the DH area (left) and a schematic of the excess heat recovery setup (right). [11]

5.5.1. General case description

Yandex, the operator of the largest search engine in Russia, decided to cut its carbon footprint and energy costs by selling excess heat from the Mäntsälä data centre. To make this possible they got in touch with the local DH operator which was looking for different heat sources to cut gas consumption and improving the competitiveness of the DH. This partnership realised by signing a heat recovery agreement with Nivos, the local energy company, brought several benefits to both partners.

The data centre operator did not have to make any design change or addition to the building. Only some extra fan power was added in order to get the waste heat out the building. The data centre was built to make full use of outside-air cooling. The whole building is shaped somewhat like aeroplane wings, with an aerodynamic profile that uses the prevailing wind to direct air through the facility at the correct pressure to provide cooling without additional power demands. Current electricity use is 10 MW, of which one third is sent to the local heating grid. Yandex can benefit of a favourable electricity tax which allows companies using over 5 MW of power to pay a lower rate. The data centre is expected to increase its electricity consumption by 40 MW and with additional efficiency improvements are expected to supply half of that for heating purposes.

The heat recovery unit produces approximately 20 GWh per year. The temperature of the air used to cool the servers exits the data centre at 37 °C. Using this excess heat as a source, a heat pump supplies DH at roughly 85 °C supplying around 1,500 households. The COP achieved by the heat pumps is around 4, depending on different factors such as ambient temperature.

This partnership has allowed the DH operator to reduce heating costs for the town residents by 5%. The system has cut the emissions from DH by 40% and has replaced about 50% of natural gas consumption of the network. Only peak loads are currently covered with the help of pellets or natural gas boilers. The DH operator is planning to add additional RE power to its energy mix to replace natural gas completely in the coming years.

5.5.2. Business model/strategy

The total investment in the heat recovery system was 2.5 million €. With electricity prices at around 23 €/MWh, replacing natural gas brings them an annual cost saving of 540,000 €, resulting in a calculated project payback time of only 4.6 years and a 22% of return on investment.

While the IT company is selling the excess heat (a new revenue stream for them), the DH company also is reducing its own gas consumption and improving its competitiveness due to the feasibility of this solution.

5.5.3. Motivation for stakeholders

The motivations for the stakeholders consist of two main components for both the DH company and the IT company:

- DH company:
 - Savings on fuel costs
 - Cut CO₂ emissions by replacing gas (and improved reputation because of it)
- IT company:
 - Revenues from selling the excess heat they produce anyway
 - Positive branding by contributing to climate solutions

5.5.4. Addressing the barriers

The process is typically key in terms of utilising excess heat. When the opportunity has been identified, the feasibility and interest for both sides i.e. heat provider and consumer (distributor) must be clarified. Businesses, who are typically not focused on the by-product of excess heat, will often not engage in selling this unless the revenue is significant, and/or the process is manageable without the need of too many (timewise) resources. The solution requires that the both sides are willing to engage in the partnership due to the foreseen benefits while, for the industry in particular, the process does not become too time-consuming, and for the DH company a trust (and contract content) is established so that the DH company can rely on the excess heat as a key source.

5.5.5. Replicability

The solution is potentially replicable in all HRE target countries as long as three key conditions are met:

- A data centre operator is willing to decarbonise its cooling consumption by recycling its own excess heat and is ready to engage in a contract – in turn to gain more revenue from selling the excess heat.
- The district heating operator is open for a partnership with new actors, is interested in reducing CO₂ emissions and wishes to improve its competitiveness.
- The business case shows a feasible connection and that the stakeholders can agree on how to share the costs and savings.

In addition, the solution requires that a heat pump manufacturer is ready to deliver a solution tailor-made for the needs of both partners. However, as the use of excess heat from various sources, like data centres, becomes even more common, likewise the supply of such large-scale heat pump options will become increasingly more commonplace.

The solution can to some extent be considered general enough to cover also other types of excess heat sources (e.g. wastewater treatment plants, underground metro systems, industrial facilities, etc.) with or without the need of a heat pump to reach the DH supply temperature.

5.5.6. Further information

- More info on engaging in the use of excess heat for district heating is found in [4].

6. References

- [1] Paardekooper S, Lund RS, Mathiesen BV, Chang MP et. al. Heat Roadmap Europe 4 : Quantifying the Impact of Low-Carbon Heating and Cooling Roadmaps. Heat Roadmap Europe Deliverable 6.4; 2018.
- [2] Builds on BPIE research and compilation by T. Adkins, "Overcoming barriers to energy efficiency retrofit measures in Swedish homes: An actor and policy analysis," Lund University, Lund, Sweden, 2011.
- [3] Lygnerud K. Challenges for business change in district heating. Energy, Sustainability and Society, 2017. doi.org/10.1186/s13705-018-0161-4 (accessed 23-11-2018).
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- [8] Best Green, www.bestgreen.dk (accessed 23-11-2018).
- [9] Michael Geissler, Berlin Energieagentur, Presentation at EMA Network 22 November 2016 in Brussels. ec.europa.eu/energy/en/events/meeting-european-network-energy-and-managing-authorities-cohesion-policy-2014-2020 (accessed 23-11-2018).
- [10] Siemens as ESCO for Hvidovre Hospital in Denmark, www.energy-supply.dk/article/view/496967/europas-bedste-energirenoveringsprojekt-ligger-i-hvidovre?ref=newsletter&utm_medium=email&utm_source=newsletter&utm_campaign=daily (accessed 23-11-2018).
- [11] Images provided by Calefa.

7. Abbreviations

ATES:	Aquifer thermal energy storage
CAPEX:	Capital expenditures
CHP:	Combined heat and power
CCHP:	Combined cooling, heating and power
COP:	Coefficient of performance
DC:	District cooling
DH:	District heating
DHC:	District heating and cooling
ESCO:	Energy service company
EPC:	Energy performance contract
ES	Energy Savings
ESP:	Energy Saving Partnerships
EU:	European Union
GHG:	Greenhouse gas
GWh:	Gigawatt-hours
H&C:	Heating and cooling
HP:	Heat pump(s)
HRE:	Heat Roadmap Europe project series starting in 2012
HRE 2050:	Heat Roadmap Scenario for 2050
HRE4	Heat Roadmap Europe 4 (H2020-EE-2015-3-MarketUptake)
MW:	Megawatt
MWh:	Megawatt-hours
OPEX:	Operational expenditures
RE:	Renewable energy
SEAP:	Strategic energy action plan
SME:	Small and medium sized enterprise(s)

Annex I. Barriers assessment table scoring references

The individual rating in scale 1 to 3 has been assessed based on the level of ambitions in the HRE 2050 decarbonisation strategy, as compared with the present (by the 2015 baseline used by HRE4) status or the countries' present path represented by the baseline scenario extended to 2050.

Explanations how the scores have been defined for each of the barriers are seen below.

Category	Barrier	Scoring Reference
? ₁	Lack of awareness of best practice for building performance measures.	Space heating demand reduction in the HRE 2050 scenario, compared to the 2015 baseline status.
? ₂	Miscommunication and a lack of integrity between the energy sector stakeholders and final customers.	Difference between recommended minimum DH share in the HRE 2050 scenario and the 2015 baseline status.
? ₃	Inadequate understanding and use of existing resources and locations for low-carbon H&C sources.	Difference in installed capacity of various RE/excess heat related H&C units (waste incineration, solar thermal, district cooling chillers, geothermal, excess heat from industry, heat recovery from fuel production) in the HRE 2050 scenario and the 2015 baseline status.
? ₄	Inadequate knowledge on the feasibility and suitable locations to apply district energy.	Difference between recommended minimum DH share in the HRE 2050 scenario and the 2015 baseline status.
€ ₁	High investment costs in energy savings measures for end-users.	Space heating demand reduction in the HRE 2050 scenario, compared to the 2015 baseline status.
€ ₂	High investment costs in low-carbon energy supply for end-users.	Difference between the installed capacity of individual heat pumps in the HRE 2050 scenario and 2015 baseline.
€ ₃	High investment costs in connecting to a thermal grid for end-users.	Difference between recommended minimum DH share in the HRE 2050 scenario and the 2015 baseline status.
€ ₄	High disproportion between peak and base heat demand, resulting in (increased costs of) supply capacity units with fewer full-load hours.	Space heating demand reduction in the HRE 2050 scenario, compared to the 2015 baseline status.

→ ₁	Reluctance of national/regional/local authorities to pursue ambitious energy savings targets, while underestimating the needs for energy savings to decarbonise the energy system.	Space heating demand reduction in the HRE 2050 scenario compared to the 2050 baseline scenario combined with targets (i.e. in case of low difference between HRE 2050 and BL 2050, but a high HRE 2050 target share, the result will be a score of 2).
→ ₂	Reluctance of national/regional/local authorities to pursue ambitious energy/climate targets, while underestimating the future needs for efficient low-carbon energy capacity.	Difference in installed capacity of various RE/excess heat related H&C units (waste incineration, solar thermal, individual heat pumps, district cooling chillers, geothermal, excess heat from industry, heat recovery from fuel production) in the HRE 2050 scenario and the 2015 baseline status.
→ ₃	Reluctance of national/regional/local authorities to pursue ambitious energy/climate targets and underestimation of the possibilities that district energy holds.	Difference between recommended minimum DH share in the HRE 2050 scenario and the 2015 baseline status.
→ ₄	Fragmented construction value chains, making the energy-saving (e.g. renovation) processes complex and disruptive to customers.	Space heating demand reduction in the HRE 2050 scenario, compared to the 2015 baseline status.
→ ₅	Fragmented construction value chains, making the implementation process of low-carbon individual H&C supply complex and disruptive to customers.	Difference between the installed capacity of individual heat pumps in the HRE 2050 scenario and 2015 baseline.
→ ₆	Fragmented construction value chains making the implementation process of DH/DC systems complex and disruptive to customers.	Difference between recommended minimum DH share in the HRE 2050 scenario and the 2015 baseline status.